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AIRTIGHTNESS OF THE LARGE PANEL BUILDINGS BEFORE AND AFTER THERMAL MODERNIZATION

SZCZELNOŚĆ BUDYNKÓW WIELKOPŁYTOWYCH PRZED I PO TERMOMODERNIZACJI

Abstract

The airtightness measurements of the system buildings are very important. They allow, together with the infrared tests, to verify all undesirable system joint leaks, which significantly increase the heating energy needs. In the article the results of airtightness measurements of two flats, built in system W-70, were presented. One of the buildings is after thermal modernization. During the leakage tests the system joints were monitored with the infrared camera. Thermograms, presented in the paper, confirmed the assumption about the negative influence of joints on the total building airtightness. Described tests are a pilot studies of the problem and provide the starting point to the further measurements on the statistical level.

Keywords: building airtightness, n_{50} coefficient, large panel buildings, system buildings, panel joints

Streszczenie

Badanie szczelności wykonywane w budynkach systemowych ma niebagatelne znaczenie. Pozwala bowiem, obok badań termowizyjnych, na zweryfikowanie wszelkich niepożądanych nieszczelności złączy systemowych, które w poważnym stopniu zwiększają zużycie energii na cele ogrzewcze. W artykule przedstawiono wyniki badania szczelności dwóch lokali mieszkalnych, wzniesionych w systemie W-70, w którym jeden został poddany zabiegom dociepleniowym. W trakcie badań szczelności monitorowano również miejsca występowania złączy systemowych przy użyciu kamery termowizyjnej. Termogramy przedstawione w artykule potwierdziły przypuszczenia o znaczącym wpływie tych newralgicznych punktów konstrukcji na całkowitą szczelność budynku. Opisane testy są pilotażowymi badaniami i stanowią punkt wyjścia do badań statystycznych.

Słowa kluczowe: szczelność budynków, wskaźnik $n_{50,}$ budynki wielkopłytowe, złącza systemowe

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1. Polish national requirements regarding airtightness measurements

At present per polish building legislation airtightness measurements are not obligatory. According to national standard *Rozporządzenie w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie* [1], it is recommended that all detached buildings, commercial building, as well as industrial buildings and all building joints between walls and connections between windows and building envelope should be designed and erected to ensure the total airtightness.

However polish regulations recommend the airtightness measurements and determining of n_{50} coefficient, which describes the number of air changes per hour at 50 Pa pressure difference. The recommended maximum values of n_{50} are as follows:

a) For buildings with natural ventilation 3,0 h^{-1},
b) For buildings with forced ventilation 1,5 h^{-1}.

Building measurements are very rare and conducted mainly in the new buildings. In practice no one make air leakage tests in the existing buildings before and after different modernizations, for example: thermal modernization.

2. Airtightness measurements according to PN-EN 13829

The airtightness measurements should be conducted according to standard PN-EN 13829 "Thermal performance of buildings. Determination of air permeability of buildings. Fan pressurization method" [2].

In the standard two different methods are acceptable depending on the purpose:

a) Method A – test of the building in use,
b) Method B – test of the building envelope.

In both methods all openings in the building envelope such as windows, doors, chimney ducts should be closed. While all interconnecting doors within the building should be opened during the entire air leakage test. All heating systems taking air from the outside, mechanical ventilation and air conditioning must be turned off. The open chimneys should be cleaned of ash. All air intake and exhaust mechanical ventilation, and air-conditioning ducts should be sealed. Openings for natural ventilation should be opened in case of method A and closed in case of method B.

What is significant, *Warunki Techniczne* does not precise, which method described by the standard should be used during tests, that is why usually they are conducted using both methods.

3. System large panel buildings – scale of the problem

It is estimated that in Poland about 4 million buildings are made of prefabricated elements in different systems. Moreover, at present more than 10 million Poles live in system large panel buildings. It makes the problems connected with the proper usage and thermal insulation to be very important and common. The most important aspect is the improvement of the building energy certificate of those buildings. It is connected with the thermal modernization of the building envelope and change of the windows.

Considering and designing the thermal modernization no one takes into consideration the discontinuity of the envelope, including joints between panels and material changeability of the vertical sections. What is more none controlling tests, airtightness or insulation improvement in the building/flat, are conducted after adding of thermal insulation.

In Poland conducting of airtightness tests in existing and modernized buildings is very rare, especially in case of prefabricated large panel buildings. Described tests are a pilot studies of the problem and provide the starting point to the further measurements on the statistical level.

4. Analyzed flats in the system buildings

Taking into account the facts above the authors conducted the airtightness measurements in two different flats located in the W-70 system buildings. The tests were conducted using the Blowerdoor set (Ill. 1) with the digital controller Retrotec 3000 and Fantestic program to analyze test data.

Ill. 1a. Blowerdoor set the in the Flat number 1

Ill. 1b. Blowerdoor set the in the Flat number 2

The first tested flat is located at the first level of the five-storey block of flats before thermal modernization (Ill. 2a) but with the new windows. It is a three room corner flat with the separate kitchen and bathroom, total area 53,4 m^2.

Second flat is located on the seventh floor of the eleven-storey block of flats after thermal modernization (Ill. 2). It is also a three room corner flat with kitchen and bathroom and with the new windows, total area 49 m^2.

Ill. 2a. Building #1 – North-East elevation

Ill. 2b. Building #2 – East elevation

The measurements were conducted in the following weather conditions:

– Building number 1 – external air temperature 15°C, wind speed in Beauford scale based on the own observation, 2 (light breeze – wind felt on exposed skin, leaves rustle); air temperature inside the flat 20°C;
– Building number 2 – external air temperature 18°C, wind speed in Beauford scale based on the own observation, 1 (light air – leaves and wind vanes are stationary); air temperature inside the flat 22°C.

Tests were conducted in two different methods. In method A, test of the building in use, the ventilation openings were not sealed. In method B, all ventilation openings were closed. During the airtightness measurements the thermal bridges and system joints were monitored using thermal camera.

Test results of both methods, for particular buildings, are presented respectively in Tables 1 and 2 and in Ill. 3 and 4.

In both buildings, 1 and 2, number of air changes n_{50}, in case of method A is much higher than permissible value of 3 h^{-1}; in building 1 value of n_{50} is almost 200% higher. However in case of method B, number of air changes, in building 1 is about 27% lower than permissible value, in building B about 40%. The difference between methods is directly connected with the dynamic air flow through the ventilation ducts. Nevertheless, the influence of system joint leaks is clearly noticeable in the tests' results.

Table 1

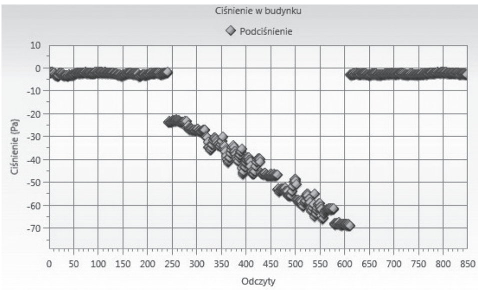
Results of airtightness test of the flat number 1

	Method A	**Method B**
Number of air changes at 50 Pa, n_{50} [1/h] **presurisation**	5.800	2.345
Number of air changes at 50 Pa, n_{50} [1/h] **depesurisation**	5.715	2.045
n_{50} [1/h]	5.757	2.195

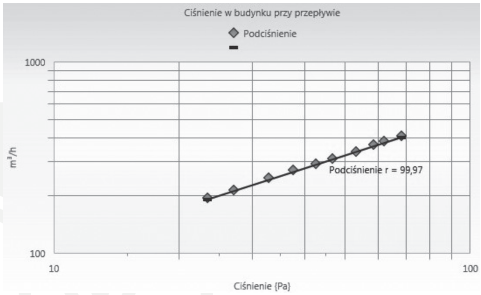
Table 2

Results of airtightness test of the flat number 2

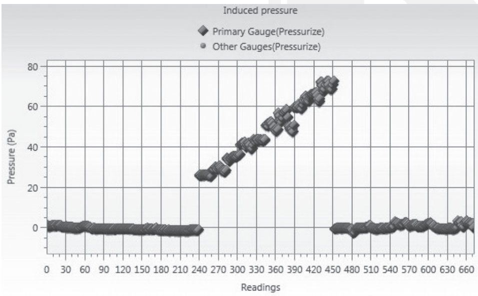
	Method A	Method B
Number of air changes at 50 Pa, n_{50} [1/h] **presurisation**	5.215	1.785
Number of air changes at 50 Pa, n_{50} [1/h] **depesurisation**	5.595	1.770
n_{50} [1/h]	5.405	1.777



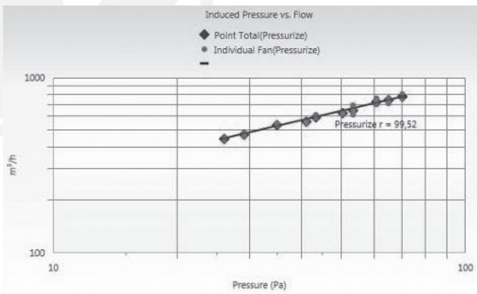
Ill. 3a. Diagram of pressure difference in building 1 – depressurization test



Ill. 3b. Relation between air flow and pressure difference in building 1



Ill. 4a. Diagram of pressure difference in building 2 – pressurization test

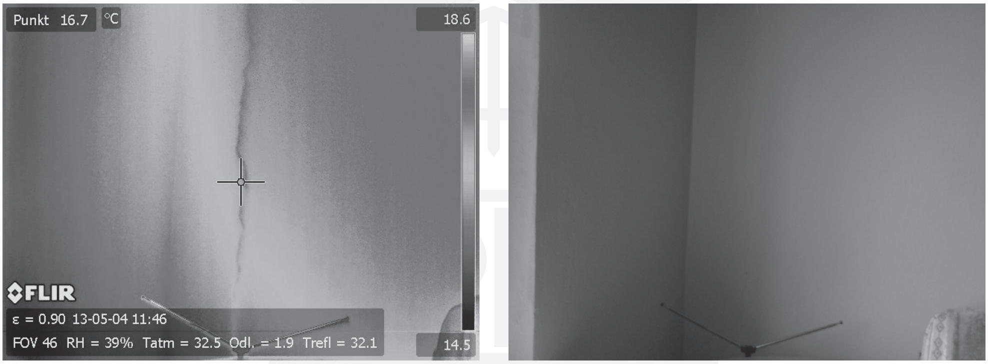


Ill. 4b. Relation between air flow and pressure difference in building 2

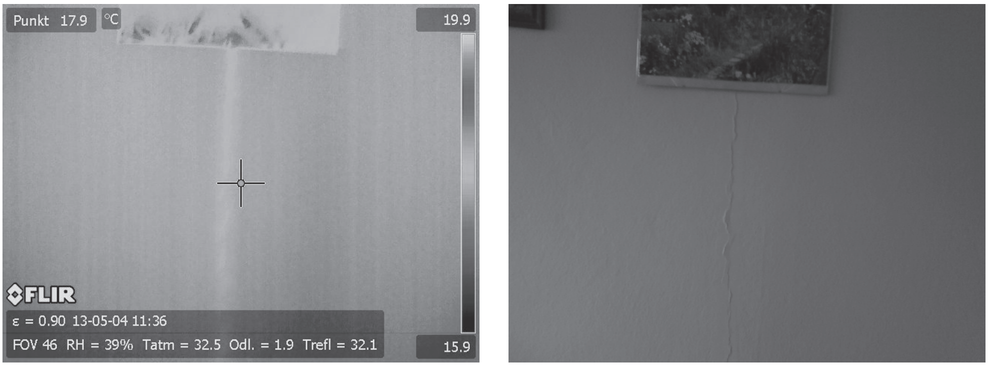
Based on the results of both tests it can be noticed that in both methods values are lower for building after thermal modernization. It proves that the use of thermal insulation eliminates discontinuities at system joints and improves the airtightness.

During the tests, the system joins in the not insulated building number 1, were monitored. In this flat, on the external walls, the vertical scratches caused by the presence of the system joints could be observed (Ill. 5 and 6). Due to the low temperature difference between the internal and external environment, only about 5°C, the infrared analysis were impeded.

Ill. 5. System joint in building number 1 – external view

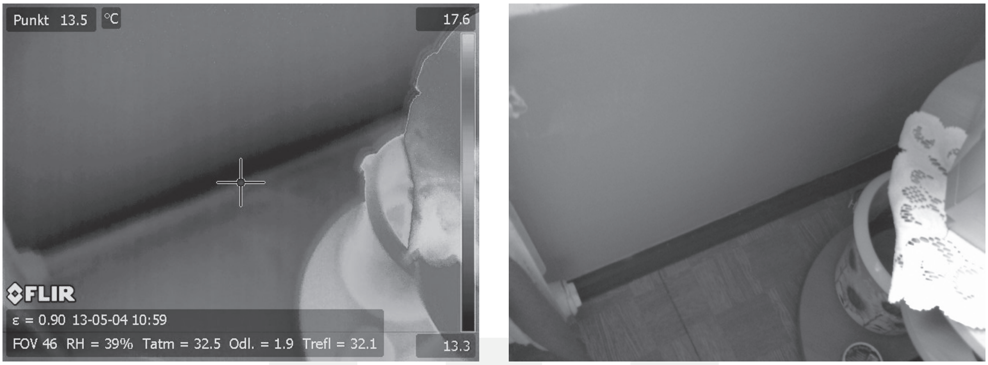


Ill. 6a. System joint – leak in place of vertical joint in building number 1



Ill. 6b. System joint – leak in place of vertical joint in building number 1

To make the monitoring possible and to increase the air flow through the joints the condition of 100 Pa underpressure was forced. It revealed the other system joint leaks: connection between floor and external wall, connections of windows, results presented in Ill. 7 and 8.



Ill. 7. Thermal bridge – connection between floor and external wall in building number 1

Ill. 8. Thermal bridge – connection between window jamb and external wall in building number 1

5. Conclusions

The conducted tests in the system buildings prove the high airtightness of the building envelopes. Results from method B in both flats were lower than the maximum acceptable values per Warunki Techniczne [1]. It is probably the result of the very precise construction of building 1 (correctly done connections) and the thermal insulation of the envelope of building 2. What is more in both building the originally mounted windows were replaced with the new ones. Nevertheless, due to the method B, number of air changes per hour in building 1 is 20% higher comparing to building 2. In case of method A, with the open ventilation ducts, the results are much higher than acceptable, in building 1 almost twice higher than maximum permissible value.

Comparing the results received in method B, it can be noticed that the leaks caused by panel joints lower the building airtightness, while the envelope insulation significantly eliminates those leaks. However the influence of the windows replacement should be taken into consideration. This problem will be the next step of the authors' researches.

The separate issue is the ventilation type and efficiency in this kind of buildings. Based on the test results it can be assumed that the amount of air removed through the ventilation ducts in system buildings is much higher than acceptable.

The measurements were conducted only in two different flats, in two different buildings. Authors plan to do much more tests in different flats and analyze the data on a statistical level. The achieved results cannot be compared with any similar test results as similar measurements have not been conducted in the prefabricated large panel buildings.

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